



Community-specific biogeochemical responses to atmospheric nitrogen deposition in subalpine ecosystems of the Cascade Range

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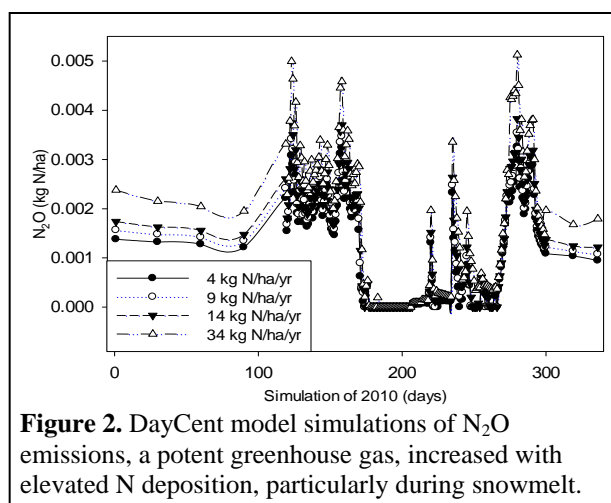
Importance

This research focuses on the impacts of atmospheric nitrogen deposition on the health and services supplied by subalpine and alpine ecosystems. Subalpine and alpine ecosystems provide important resources for Mount Rainier National Park. They act as carbon sinks that slow the greenhouse effect and function as a filter for atmospheric pollutants that deposit in rain and snowfall. Additionally, they support a famous diversity of wildflowers that provides forage for wildlife and brings visitors to the Park. However, these important resources may be diminishing due to increases in atmospheric nitrogen deposition.



Figure 1. The ecosystem services of subalpine meadows in the Paradise area may be vulnerable to elevated rates of atmospheric N deposition.

Atmospheric nitrogen deposition occurs when reactive nitrogen (N) gases in the atmosphere fall out with precipitation or attach to airborne particles, like dust or pollen. These reactive N gases are released into the atmosphere by automobile or industrial emissions or by the volatilization of fertilizer applied to farmland. Although small amounts of reactive N can improve plant growth, large amounts of N deposition can over-saturate ecosystems (Aber et al., 1989). Alpine and subalpine ecosystems are particularly vulnerable to reactive N saturation because they have thin soils and short vegetation growing seasons, which prohibit the use of excess N for growth (Fenn et al., 2003) (Fig. 1). This over-saturation causes reactive N to leak out of the ecosystem, which results in increased emissions of greenhouse gases, leaching of reactive N to pristine montane watersheds, and eventual deterioration of subalpine wildflower communities (Aber et al., 1989). Deposition shifts ecosystems that used to be greenhouse gas sinks into sources, particularly for carbon dioxide (CO₂) and nitrous oxide (N₂O), amplifying the greenhouse effect. In addition, it can cause pollution of mountain lakes and streams through acidification and eutrophication, which negatively impact their quality for recreation and as drinking water (Fig. 2). Furthermore, deposition makes fragile wildflower communities more susceptible to invasion by weeds from



with the greatest activity occurring during snowmelt (Fig. 2). Soil sampling was conducted on three vegetation communities in the Paradise area of Mount Rainier National Park in 2012 to evaluate the current N status of the soil, determine patterns of N cycling, and parameterize the modeling efforts.

Status and Trends

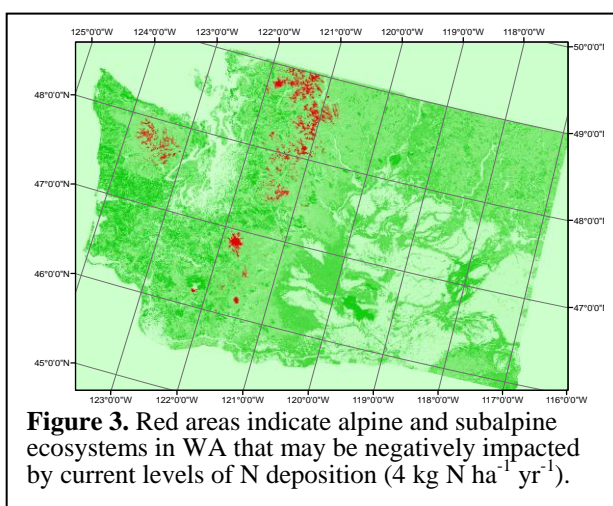
The National Atmospheric Deposition Program (NADP) has measured rates between 1.5 to 30 kg N ha⁻¹ yr⁻¹ (10x to 60x natural background rates) of inorganic N deposition throughout the Pacific Northwest (Fenn et al., 2006; NADP, 2012). These rates vary seasonally, with most of N deposition falling in snowpack and the least deposition falling during summer months (NADP, 2012). Subalpine and alpine ecosystems, which receive larger proportions of precipitation than lower elevations, have been shown to receive higher rates of N deposition as well (Fenn et al., 2003). Previous research has indicated that most of the subalpine and alpine ecosystems in the Cascades, including those in Mount Rainier National Park, where current N deposition levels (2.35 to 5 kg N ha⁻¹ yr⁻¹) may be detrimental to ecosystem health and services (Fig. 3) (NADP, 2012; Poinssatte et al., 2012). However, how the sources and impacts of N deposition for high-elevation ecosystems is still not well understood.

Discussion

The 2012 soil sampling in the Paradise area suggest that the subalpine soils have low carbon to nitrogen (C:N) ratios, a sign of relatively N rich soils. Additionally, these results indicate that these subalpine soils are dominated by C inputs from C₃ vegetation and N inputs by N₂-fixing legumes. Prior studies have indicated that soils with low C:N ratios have higher susceptibility for greenhouse gas production and reactive N leaching with elevated rates of atmospheric N deposition (Dise et al., 1998). These results will be evaluated with measurements of N_2O emissions rates, inorganic N fluxes in the soil, plant N uptake rates, and N leaching rates in the

lower elevations (Fenn et al., 2003). Thus, increases in N deposition could have huge impacts for Mount Rainier National Park and high-elevation ecosystems throughout the Cascades.

This study is utilizing a combination of biogeochemical modeling and field experimentation to evaluate the impacts of atmospheric N deposition in subalpine ecosystems. Preliminary DayCent biogeochemical model simulations of these impacts have been performed for the Paradise area of Mount Rainier National Park. These simulations indicate that elevated atmospheric N deposition will increase soil N concentrations, rates of greenhouse gas production, and reactive N leaching to watersheds,



summer of 2013. These measurements will inform National Park Service management as to the baseline status of N cycling in subalpine and alpine ecosystems and highlight which ecosystem services might be especially vulnerable to increases in N deposition.

Literature Cited

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